TF 2153 Series

TF 2153, TF 2154 and TF 2155 series

D.C. Power Supply

INSTRUCTION MANUAL

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MARCONI INSTRUMENTS

Instruction Manual
No. EB 2153
for

D.C. Power Supply TF 2153, TF 2154 and TF 2155 series

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

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Fig 6.1 Auxiliary PCB Circuit Diagram (Centre Tap Versions)
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Chapter 1

General information

1.1 INTRODUCTION

The TF 2153, TF 2154 and TF 2155 offer a series of bench power supplies covering the range 60 V at 0.5A to 5 V at 4A. In addition optional versions provide centre tapped outputs.

All units use the same basic case and internal construction with identical heat sinks and main printed circuit board, changes to component values and types determine the difference between the units.

The centre tap version has an additional circuit board, together with a pair of extra power transistors. In this mode current limit control operates on both rails.

A large 2 scale meter provides monitoring of current and voltage.

A unique push button system provides 9 output ranges. Single button operation selects the four main output ranges and dual button operation allows the alternative current limits to be also selected.

1.2 DATA SUMMARY

Output Power

TF 2153	0 - 15 watts
TF 2154 & TF 2155	0 - 30 watts

Modes

TF 2153	5 V ±1% at 0.5A, 1A, 2A 0 to 7.5 V at 0.5A, 1A, 2A 0 to 15 V at 0.5A, 1A 0 to 30 V at 0.5A
TF 2154	5 V ±1% at 1A, 2A, 4A 0 to 7.5 V at 1A, 2A, 4A 0 to 15 V at 1A, 2A 0 to 30 V at 1A
TF 2155	5 V ±1% at 0.5A, 1A, 2A 0 to 15 V at 0.5A, 1A, 2A 0 to 30 V at 0.5A, 1A 0 to 60 V at 0.5A
TF 2153/1, TF 2154/1 and TF 2155/1	as above plus centre-tap facility.
Current Limit	Greater than selected full load current (nominally 110%).
Line regulation	<0.02% of maximum voltage range selected for a 10% line change.
Load regulation	<0.05% of maximum voltage range selected for a 100% load change.
Transient response	Recovers to 50 mV within 20 μs for full load step change

Ripple and Noise	1 mV peak-peak.
Centre Tap Tracking (TF 2153/1, TF 2154/1 and TF 2155/1 only)	49% to 51% of total output ±100 mV (down to 4 V total output).
Meter Range	
TF 2153 Series	0-10 V and 0-30 V ; 0-1A and 0-3A.
TF 2154 Series	0-10 V and 0-30 V ; 0-2A and 0-6A.
TF 2155 Series	0-20 V and 0-60 V ; 0-1A and 0-3A
Temperature Coefficient	Typically 0.02% per °C at 25 °C
Operating Temperature	0-45°C
Output Impedance	15 mΩ at 1 kHz (typically)

Dimension	Height	Depth	Width
	180 mm (7 inch)	255 mm (10 inch)	153 mm (6 inch)

Weight

TF 2153	4 kg	(8 lb 13 oz)
TF 2153/1	4.1 kg	(9 lb)
TF 2154 & TF 2155	4.4 kg	(9 lb 11 oz)
TF 2154/1 & TF 2155/1	4.5 kg	(9 lb 14 oz)

Chapter 2

Operation

2.1 INSTALLATION

To ensure adequate cooling of the heat sinks it is important to maintain free circulation of air.

CAUTION

Make sure that the mains lead is kept well clear of the heat sink when in use.

Do not use the power supplies stacked one upon another.

2.2 POWER SUPPLY

The units are supplied ready for use with 240 V a.c. 50 Hz mains supply and will work satisfactorily within the specification limits of ±10%.

2.2.1 Transformer Tapping

Alternative primary tappings are provided for line voltages of 110 V, 120 V and 220 V. Simply reset the rubber moulded plug, located on the rear of the instrument, so that the horizontal mark is aligned with the required mains voltage.

2.2.2 Fuse replacement

The fuse holder is located on the rear panel. It should be noted that fuse ratings should be doubled when the instrument is used with 110/120 V mains supply.

Instrument	Fuse Rating	Part Number
TF 2153 Series	110/120 V a.c. 1 amp	FPP/2153/23402
	220/240 V a.c. 0.5 amp	FPP/2153/23401

2.2.3 Mains Plug connection

A suitable mains plug must be connected to the captive power lead by the user. The three connectors are colour coded to the international standard as follows :

Brown	-	Live
Blue	-	Neutral
Green/Yellow	-	Earth

WARNING

Connection to a supply with no earth is dangerous.

2.3 OPERATING PROCEDURE

Before connecting the unit to the mains supply ensure that the mains transformer tapping is correctly set and that the appropriate mains fuse is fitted, then proceed as follows :-

(i) Ensure that the supply switch is in the off position, by releasing the RED push button.

(ii) Connect the appropriate output terminals to the load as required.

On the standard units (e.g. TF 2153) the full output voltage is across the BLACK (negative) and RED (positive) terminals. Either terminal can be connected to the earth terminal (GREEN) to determine the polarity of the output.

The centre tap versions (e.g. TF 2153/1) provides either the full output voltage across the negative and positive terminals, or two supplies at half voltage, symmetrically about the centre-tap. In this mode the current limit will operate if the current in either half of the supply exceeds the limit value. Both halves of the supply, however, will be reduced in voltage together as the current limit operates.

(iii) Select the required voltage range by operating the appropriate GREY push button. The current limit will be as indicated on the front panel calibration.

If a current limit lower than the maximum already selected is required, simply also select a second appropriate push button.

If more than one grey push button is depressed at a time, the output supply will correspond to the lowest selected voltage and the output current limit to the lowest selected current.

NOTE

This facility as well as providing a total of 9 output ranges also affords a level of load protection if more than one range is inadvertantly selected.

(iv) Select the appropriate meter range. With both BLACK push-buttons released, the meter reads output voltage with a full scale equal to the highest range.

Depressing the top meter push-button changes the meter to current reading.

Depressing the lower button increases the meter sensitivity by a factor of 3 on both voltage and current.

On centre-tapped units, the meter reads the total supply voltage on voltage ranges and whichever is the higher of the load currents on current ranges.

(v) Turn the VOLTAGE LIMIT control fully anti-clockwise. Note that selection of the lowest grey button gives a 5 V output regardless of the position of the voltage limit control.

The output voltage control is not calibrated.
Note that, in order to ensure full voltage availability on all ranges, a small amount of voltage overrange is provided. Similarly, in order to ensure full current availability the nominal current limit values are 10% higher than the values marked.

(vi) Switch on the power supply by pressing the RED button. The adjacent lamp will illuminate to indicate correct working.

(vii) Adjust the voltage control for the required voltage as indicated on the meter.

2.4 SERIES AND PARALLEL CONNECTED

To obtain extra power, higher voltage or multi-rail configurations, units may be connected in series.

Parallel operation is not recommended since, unless the output voltages are set precisely equal, a step in output voltage will occur at half the total output current as one unit enters 'current limit'.

The multi-range capability of these units largely obviates the need for parallel operation. For example - two TF 2153 will provide 30 V at 2A by connecting them in series (2x15 V at 2A) rather than in parallel (2x1A at 30 V).

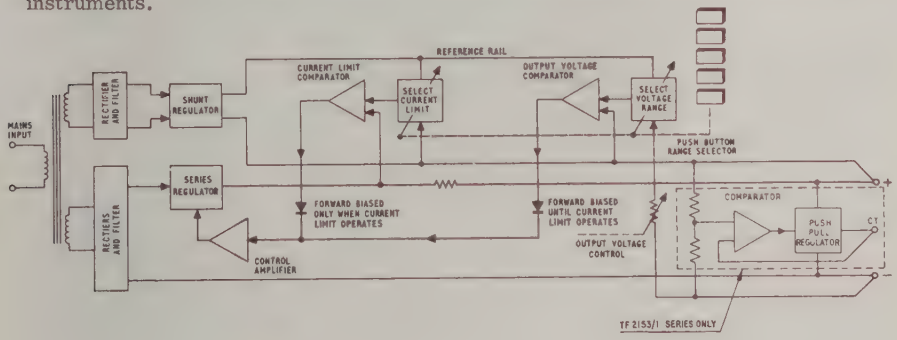
The limit imposed by the safe working voltage (300 V) controls the number of units that can be connected in series.

Chapter 3

Technical description

3.1 INTRODUCTION

The TF 2153, TF 2154 and TF 2155 are identical in function and mechanical layout. Only a few component values are changed. The block diagram Fig 3.1, the circuit diagrams Fig 6.1 and Fig 6.2 and the following description are applicable to all instruments.



3.2 GENERAL DESCRIPTION

The a.c. input is protected by FS1, double pole switched by S7A and S7B and is applied to transformer primary via the voltage selector. This connects the primaries in series or parallel and adjusts the taps to suit the input voltage. The secondaries are connected in series or parallel by S3A, S4A, S5A and S6A to provide the correct unregulated voltage for the selected range.

With S6 or S5 depressed, secondary 3 is connected in parallel with the series combination of secondaries 1 and 2 to give the lowest voltage, highest current output to the rectifier. If either S3 or S4 is depressed at the same time, the combination of secondaries 1 and 2 is disconnected; as this action automatically lowers the current limit, secondary 3 can supply the load. With S4 depressed, secondaries 1 and 3 are connected in series for the middle output range; depressing S3 simultaneously with S4 has no effect as S4 has disconnected one end of the secondary 2. With S3 depressed, secondaries 1, 2 and 3 are connected in series to supply the highest voltage range.

The a.c. output from the transformer is rectified by MR2, MR3, MR4 and MR5 (BR1 on 413), with C2 acting as the reservoir capacitor. VT10 (and VT11

on 413 and 423) is the series regulator transistor with R29 providing current sensing. On 413 and 423, R29 and R30 also act to ensure current sharing between VT10 and VT11. The output is decoupled by C8 (C13 on centre-tapped units) with MR13 acting as protection against reverse voltage in the event of one supply being switched off when two supplies are being used in series.

Secondary 4 of the transformer is a low current secondary supplying power to the control and driver circuits. Its output is rectified by MR1 and filtered by C1. Note that the negative rail of the control supply is common to the positive rail of the output. R21, R22, VT8 and MR12 act as a constant current source supplying current to the main reference rail. This rail is stabilised by the amplifier VT6 and VT7, with MR11 acting as feedback round this amplifier. The regulated rail is, therefore, 5.6 V plus the base emitter forward voltage of VT6 and appears at the emitter of VT7. R19 sets the standing current through MR11. The excess current from the collector of VT7 is used as the base drive for the driver transistor VT9.

R2 and RV2 provide a preset adjustable voltage for the voltage amplifier on the variable ranges. R5, R6 and R7 convert this into a reference current. Depressing S5 connects R5, R6 and R7 in series to provide the lowest reference current and, hence, the lowest output voltage range; as S5B has disconnected S4B and S3B, depressing these simultaneously does not affect the output voltage. Depressing S4 connects R5 and R6 in series to give the middle range: again, S4B disconnects S3B so that depressing S3B does not affect the output voltage. With S3 depressed, R5 provides the reference current. This switching arrangement ensures that the output is always the lowest of the selected voltages.

The reference current is balanced against the feedback current drawn by RV6 through MR7 and, as the base current of VT1 is negligible, these are equal. Note that, as the bases of VT1 and VT6 are both one forward-biased diode voltage drop above the positive output, their emitter base voltage drops cancel and MR11 determines the voltage across R5, R6 and R7. Similarly, the forward voltage drop of MR7 cancels the forward voltage drop of VT1 base, so that the voltage across RV6 is equal to the output voltage. Temperature variations in VT1, VT6 and MR7, therefore, cancel.

The action of the feedback loop is as follows: Should the output voltage increase, the extra current through RV6 causes VT1 to turn off slightly, reducing its collector current. Some of the current from R8, therefore, diverts through MR9 and into the emitter of the common base stage VT3. This current flows from the collector of VT3 into the base of VT4, causing its collector current to increase. As a result, emitter follower VT5 also draws more current from VT7, reducing the drive to VT9 and, hence, the output stages. This, therefore, causes a change in output to oppose the initial change and stabilises the output voltage.

C3 gives increased gain at a.c. to minimise ripple. R42 helps to define the gain of VT1. R17 and C4 provide the main loop time constants. C14 and C7

suppress possible parasitic oscillations. When S6 is depressed, the variable control system is disconnected from VT1 base. An adjustable reference current through R3 and RV3 and a fixed feedback current through R4 and MR6 are connected to VT1 base to give the fixed 5 V output.

The current limit circuitry operates in a similar manner. The reference current is derived from the adjustable divider R1 and RV1, with R9, R10 and R11 as the series resistors. The switching in this case is arranged to allow only the lowest current limit selected to operate. The feedback current is through R12 and MR8. The voltage drop across MR8 cancels the base emitter voltage of VT2 so that the voltage across R12 is equal to that across R29. Similarly, the base emitter voltages of VT2 and VT6 cancel to stabilise the reference current. The output of the current sensing stage is OR-gated into the emitter of VT3 by MR10. C6 provides extra stabilisation of the loop in current limit mode.

The meter switching is entirely straightforward. RV4 on the voltage ranges or RV5 on the current ranges is adjusted to shunt the meter and obtain calibration. S1A and S1B switch the meter between voltage and current ranges. S2A on voltage and S2B on current short out part of the series chain to give the more sensitive meter ranges.

The circuit of the centre tap section, used only on option units, is shown in Fig 6.1. On the option units, the auxiliary unregulated supply is regulated by R31 and MR14. This supply provides, via R34 and VT12, a constant current to the differential pair VT13 and VT14. These compare the centre tap voltage with a centre point voltage derived by divider R32 and R33. This differential pair drives the Darlington connected pair VT16 and VT17 which, in turn, drive the class 'B' push/pull output stage VT18, VT19, VT20 and VT21. R37 and VT15 form another current source, providing a dynamic load for VT16 and VT17. Output capacitors C8 and C9 are added to give good centre tap ripple and transient response. C10 and R39 determine the loop frequency response.

Chapter 4

Maintenance

4.1 INTRODUCTION

This section contains information for keeping the equipment in good working order and for checking its overall performance.

Performance limits quoted are for guidance only and should not be taken as guaranteed performance spefification unless they are also quoted in the Data Summary (Chapter 1.2).

In the case of incorrect operation, the location of the faulty component will be greatly simplified by reference to the circuit description and to the circuit diagrams (Fig 6.1 and 6.2).

In case of difficulty, please write to or phone, the Marconi Instruments Service Division quoting the type and serial number on the base panel. If the instrument is being returned for repair please indicate clearly the nature of the fault or the work you require to be done.

4.2 ACCESS AND LAYOUT

Remove the cover from the unit by releasing the two screws holding the carrying handle and four small screws (two on each side) from the sides of the cover. Access to all preset potentiometers is gained through holes in the printed circuit board ; their functions are marked on both sides of the board.

All units use the same basic case and internal construction with identical heat sinks and main printed circuit board upon which are mounted all of the pre-set components, changes to component values and types determining the difference between the units. The centre-tap versions (/1) have an additional circuit board which controls the centre-tap, together with a pair of extra power transistors on the heatsink.

The printed circuit boards are each retained by four corner screws, thus for fault finding purposes their removal is easily acheived. All components are identified by a clearly marked legend on each board.

4.3 PERFORMANCE CHECK AND RE-ALIGNMENT PROCEDURE

The procedure outlined in this section will also constitute a performance check. It is in general applicable to all TF 2153 series but where data is not compatable to all units the alternative figures are given in brackets.

The TF 2671 Digital Multimeter is suitable for most checks except for the 4 amp current adjustment in which case the TF 2650 Masteranger Multimeter with its current shunt is appropiate.

Proceed as follows :-

(i) Adjust the meter mechanical zero then connect the unit to the mains and switch on. Connect the multimeter to the output terminals.

(ii) Adjust the variable voltage control fully clockwise and depress the 7.5 V (15 V on TF 2155) push-button. Adjust the 'SET V' (RV2) control to give an output of 7.6 V (15.2 V on TF 2155).

Release the 7.5 V (15 V on TF 2155) push-button and depress the 15 V (30 V on TF 2155) button. Check that the output voltage is 15.4 V ±0.4 V (30.8 ±0.8 V on TF 2155).

Release the 15 V (30 V on TF 2155) push-button and depress the 30 V (60 V on TF 2155) button. Check that this output voltage is 30.8 V ±0.8 V (61.5 ±1.5 V on TF 2155).

(iii) Select the high voltage metering range by releasing both meter push-buttons. By means of the variable voltage control set the output voltage as monitored by the TF 2671 to 30.0 V (60.0 V on TF 2155). Adjust 'SET METER V' (RV4) so that the meter reads 30.0 V (60.0 V on TF 2155).

Reduce the output voltage as monitored by the TF 2671 to 10.0 V (20.0 V on TF 2155). Select the lower voltage metering range by depressing the lower meter push button and check that the meter reads 10.0 ±0.2 V (20.0 ±0.4 V on the TF 2155).

Release the lower meter button.

(iv) Set the variable voltage control fully clockwise and short circuit the unit through a d.c. ammeter.

NOTE : The TF 2671 current measurement ranges are sufficient for all checks of up to 2 amps. If higher readings are to be made an alternative d.c. ammeter will be required (e.g. TF 2650 MASTERANGER Multimeter).

Adjust 'SET A' (RV1) to give a short circuit current of 0.55 A (1.1 A on TF 2154).

Release the 30 V (60 V on TF 2155) push-button and depress the 15 V (30 V on TF 2155) button. Check that the short circuit current is 1.1 ±0.1 A (2.2 ±0.2 A on TF 2154).

Release the 15 V (30 V on TF 2155) push-button and depress the 7.5 V (15 V on TF 2155) button. Check that the short circuit current is 2.2 ±0.2 A (4.4 ±0.4 A on TF 2154).

(v) Remove the short circuit and reconnect the TF 2671 as a voltmeter.

Release the 7.5 V (15 V on TF 2155) push-button and depress the 5.00 V button. Adjust 'SET 5V' (RV3) to give an output of 5.00 V ±0.01 V.

(vi) Select the higher ammeter range by depressing the top meter push-button. Apply a load via a d.c. ammeter of 2.0 A (4.0 A on TF 2154) and adjust 'METER A' (RV5) so that the meter reads 2.0 A (4.0 A on TF 2154).

Reduce the load current to 1.0 A (2.0 A on TF 2154), depress the lower meter push-button and check that the meter reads 1.0 ±0.02 A (2.0 ±0.04 A on the TF 2154).

The unit is now aligned. Replace the cover.

4.4 PACKAGING FOR RESHIPMENT

In the event of the equipment being returned for servicing it should be packed in the original shipping carton and packing material. If this is not available wrap the instrument in heavy plastic and place in a rigid box, preferably of wood, fibre board of very strong corrugated cardboard. Use ample soft packing to prevent movement. Provide additional support for projecting parts to relieve these of unnecessary shock. Close the carton securely and seal with durable tape. Mark the shipping container FRAGILE to ensure careful handling.

Chapter 5

Replaceable parts

5.1 INTRODUCTION

All versions of the TF 2153 Series Power Supplies use the same printed circuit board, changes to component values and types determine the difference between the units. The centre tap versions have an additional printed circuit board fitted. This parts list is therefore applicable to all versions.

A 'used on' column adjacent to the component reference number indicates on which unit the particular component is used. For this purpose the following code applies :-

00	all units - TF 2153, TF 2153/1, TF 2154, TF 2154/1, TF 2155, TF 2155/1
01	all /1 versions - TF 2153/1, TF 2154/1, TF 2155/1
02	all standard versions - TF 2153, TF 2154, TF 2155
03	all TF 2153 versions - TF 2153, TF 2153/1
04	all TF 2154 versions - TF 2154, TF 2154/1
05	all TF 2155 versions - TF 2155, TF 2155/1
30	TF 2153 only
31	TF 2153/1 only
40	TF 2154 only
41	TF 2154/1 only
50	TF 2155 only
51	TF 2155/1 only

Example - BR1 04 (MDA99-2) is used only on TF2154 and TF 2154/1

For spares ordering purposes the following table shows the codes relevant to each unit.

TF 2153	-	00, 02, 03 and 30
TF 2153/1	-	00, 01, 03 and 31
TF 2154	-	00, 02, 04 and 40
TF 2154/1	-	00, 01, 04 and 41
TF 2155	-	00, 02, 05 and 50
TF 2155/1	-	00, 01, 05 and 51

Example - For a full set of components for the TF 2154/1 order all components coded 00, 01, 04 and 41.

The circuit reference numbers are listed in alpha-numerical order. The following abbreviations are used :-

C	capacitor	PL	pilot lamp
Cer	ceramic	Plas	plastic
FS	fuse	R	resistor
L	inductor	RV	variable resistor
M	meter	S	switch
Met	metal	T	transformer
MR	diode	W	watts
Ox	oxide	WW	wire wound

5.2 ORDERING

When ordering replacements or spare parts, address the order to our Service Division (for address see rear cover) or nearest representative. Please specify the following information for each part required.

(i) Type and Serial Number (see rear and base panels)
(ii) Complete circuit reference
(iii) Description of part
(iv) M.I. Part Number

If a part is not listed, state its function, location and description when ordering.

Spares supplied against M.I. part numbers are electrically interchangeable with those originally fitted, but may not always be identical.

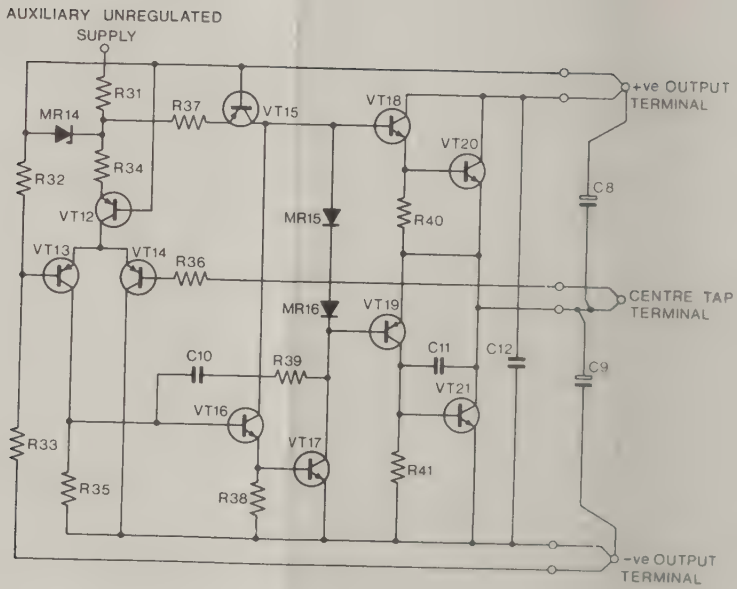
6.3 PARTS LIST

Circuit reference	Used on	Description		M.I. code No. (TF 2153/FPP/.....)
Bridge Rectifier				
BR1	04	MDA 990-2 Motorola		28101
Capacitors				
C1	00	470µF -10+50% 35/40V	Elect	26005
C2	03	2200µF -10+50% 63V	Elect	26006
C2	04	4700µF -10+50% 63V	Elect	26007
C2	05	2200µF -10+50% 100V	Elect	26008
C3	03/04	2.2µF -10+50% 63V	Elect	26009
C3	05	2.2µF -10+50% 100V	Elect	26010
C4,6	00	2200pF -20+50% 500V	Cer	26011
C5,7	00	1000pF -20+50% 500V	Cer	26012

Circuit reference	Used on	Description		M.I. code No. (TF 2153/FPP/.....)
C8	03/51	100µF -10+50% 35/40V	Elect	26001
C8	40	220µF -10+50% 35/40V	Elect	26002
C8	41	220µF -10+50% 25V	Elect	26003
C8	50	100µF -10+50% 100V	Elect	26004
C9	02	Not fitted		
C9	31/51	100µF -10+50% 35/40 V	Elect	26001
C9	41	220µF -10+50% 25V	Elect	26003
C10-12	02	Not fitted		
C10	31/51	1000pF ±20% 500V	Cer	26012
C10	41	390pF ±20% 500V	Cer	26014
C11	01	2200pF ±20% 500V	Cer	26011
C12	01	0.1µF ±20% 100V	Plas Film	26015
C13	02	Not fitted		
C13	31	100µF -10+50% 35/40V	Elect	26001
C13	41	220µF -10+50% 35/40V	Elect	26002
C13	51	100µF -10+50% 100V	Elect	26004
C14	00	220pF -20+50% 500V	Cer	26013
Fuses				
FS1	00	0.5 A anti-surge (240V) 20 x 5 mm		23401
FS1	00	1 amp anti-surge (115V) 20 x 5 mm		23402
Inductor				
L1/2	00	Ferrite Bead Mullard FX1115		43201
Meter				
M1	03	Meter Weir W1567		44501
M1	04	Meter Weir W1568		44502
M1	05	Meter Weir W1569		44503
Diodes				
MR1	00	1N4002		28102
MR2-5	03/05	1N4140 (BR1 used on TF 2154 Series)		28103
MR6-10	00	1N4148		28104
MR11	00	BZY 88 C5V6		28105
MR12	00	BZY 88 C8V2		28106
MR13	00	1N4140		28103
MR14	01	BZY 88 C5V6		28105
MR15,16	01	1N4148		28104
Indicator Lamp				
PL1	00	Pilot Lamp (red) 110V		23701

Circuit reference	Used on	Description	M.I. code No. (TF 2153/FPP/.....)
Resistors			
R1	00	2k ±2% ½W	Met Oxide 24001
R2,15,22	00	2.2k ±2% ½W	Met Oxide 24002
R3,4,10	00	20k ±1% ½W	Met Film 24003
R5,6,11	00	8.2k ±1% ½W	Met Film 24004
R7	00	16k ±1% ½W	Met Film 24005
R8,12	00	2.7k ±2% ½W	Met Oxide 24006
R9	00	10k ±1% ½W	Met Film 24007
R13	00	10k ±2% ½W	Met Oxide 24008
R14	00	5.6k ±2% ½W	Met Oxide 24009
R16,18	00	1.5k ±2% ½W	Met Oxide 24010
R17,19	00	120 ±2% ½W	Met Oxide 24011
R20	00	680 ±2% ½W	Met Oxide 24012
R21	00	330 ±2% ½W	Met Oxide 24013
R23	00	27 ±2% ½W	Met Oxide 24014
R24	00	330 ±1% ½W	Met Film 24015
R25	00	36 ±1% ½W	Met Film 24016
R26	00	750k ±1% ½W	Met Film 24017
R27	03/04	15k ±1% ½W	Met Film 24018
R27	05	30k ±1% ½W	Met Film 24019
R28	03/04	7.5k ±1% ½W	Met Film 24020
R28	05	15k ±1% ½W	Met Film 24018
R29	03/04	0.5 ±5% 3W	WW 24021
R29,30	05	1.0±5% 3W	WW 24022
R30	03	Not fitted	
R30	04	0.5 ±5% 3W	WW 24021
R31	01	1k ±2% ½W	Met Oxide 24025
R32,33	01	6.8 ±1% ½W	Met Film 24026
R34	01	56k ±2% ½W	Met Oxide 24027
R35	01	27k ±2% ½W	Met Oxide 24028
R36	01	3.3k ±2% ½W	Met Oxide 24029
R37	31/51	1.5k ±2% ½W	Met Oxide 24010
R37	41	820 ±2% ½W	Met Oxide 24030
R38	01	4.7k ±2% ½W	Met Oxide 24031
R39	01	120 ±2% ½W	Met Oxide 24011
R40,41	01	27 ±2% ½W	Met Oxide 24014
R42	00	47 ±2% ½W	Met Oxide 24024

Circuit reference	Used on	Description		M.I. code No. (TF 2153/FPP/.....)
Transistors				
VT1,2,6	00	BC107		28203
VT3	03/04	BCY70		28204
VT3	05	2N3963		28205
VT4	03/04	BC107		28203
VT4	05	MPSA06	Motorola	28206
VT5	03/04	BFX29		28207
VT5	05	BD528		28208
VT7,8	00	BCY70		28204
VT9	03/04	BD577		28209
VT9	05	BD581		28210
VT10	30	2N3055		28201
VT10,20, 21	31	2N3055		28201
VT10,11	40	2N3055		28201
VT10,11 20,21	41	2N3055		28201
VT10,11	50	2N3055 (selected for 120V $_{CER}$ at 27R)		28202
VT10,11, 20,21	51	2N3055 (selected for 120V $_{CER}$ at 27R)		28202
VT12,13 14,15	01	BCY70		28204
VT16,17	01	BC107		28203
VT18	01	BD577		28209
VT19	01	BD578		28211
Miscellaneous				
Terminals		+ve Output	B/Lee L1568/2CA Red	23001
		-ve Output	B/Lee L1568/2CA Black	23002
	01	CT Output	B/Lee L1568/2CA Blue	23003
	02	Earth	B/Lee L1568/2CA Green	23004
Fuse Holder	00	Bulgin F330		23403
Knob	00			
Variable Resistors				
RV1,2	00	500 ±20%	Carbon	25003
RV3	00	5k ±20%	Carbon	25004
RV4,5	00	100 ±20%	Carbon	25005
RV6	03/04	50k ±10% 1W	WW Cermet	25001
RV6	05	100k ±10% 1W	WW Cermet	25002
Switch Assembly				
(S1-7)	00	AB400-F02020-08-0-00		23101
Transformers				
T1	03	Mains Transformer	Weir W1556	43101
T1	04	Mains Transformer	Weir W1557	43102
T1	05	Mains Transformer	Weir W1558	43103



Marconi Instruments Ltd.
TF2153/1 TF2154/1 and TF2155/1

Fig. 6.1 Auxiliary PCB Circuit Diagram

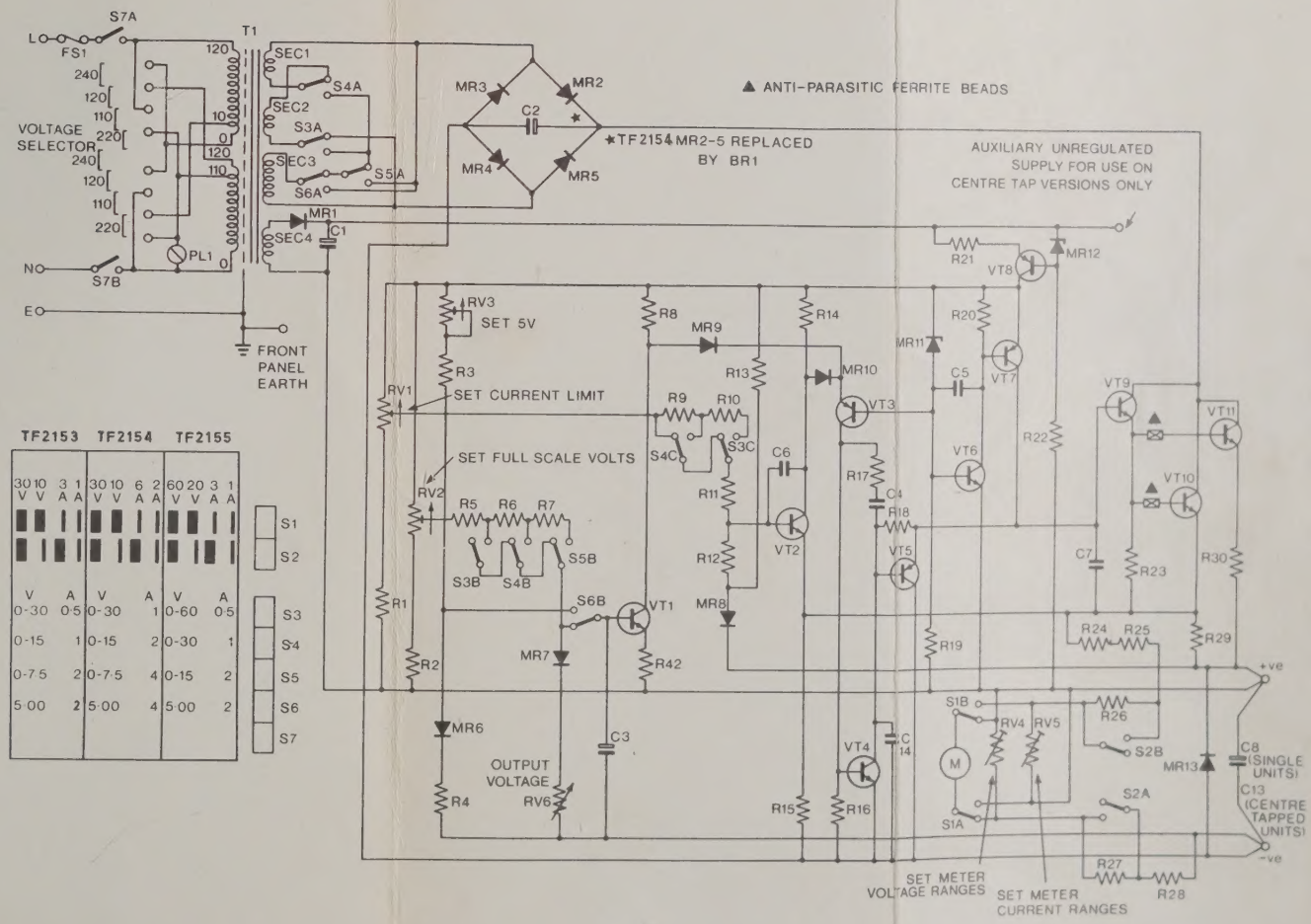


Fig. 6.2 Main Assembly PCB Circuit Diagram

MARCONI INSTRUMENTS LIMITED

SERVICE DIVISION	**THE AIRPORT, LUTON, BEDFORDSHIRE LU2 9NS** *Telephone : Luton 33866*
HOME and EXPORT SALES OFFICES	**LONGACRES, ST. ALBANS, HERTFORDSHIRE AL4 0JN** *Telephone : St. Albans 59292* *Telegrams : Measurtest, St. Albans* *Telex : 23350*
U.S.A.	**MARCONI INSTRUMENTS DIVISION, MARCONI ELECTRONICS INC., 100 STONEHOUSE COURT, NORTHVALE, NEW JERSEY 07647** *Telephone : (201) 767-7250* *Telex : 710-991-9752*
BUNDESREPUBLIK DEUTSCHLAND	**MARCONI MESSTECHNIK G.m.b.H., P.O. BOX NO. 210330 JOERGSTRASSE 74 8 MUNICH 21** *Telephone : 582041* *Telex : 05 24642*
FRANCE	**MARCONI INSTRUMENTS, SUCCURSALE DE FRANCE, 32 AVENUE DES ECOLES, 91600 SAVIGNY SUR ORGE** *Telephone : 921.93.86* *Telex : 60541*

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